Report for 2003MS16B: Improved Estimation of Nutrient and Pesticide Runoff Losses from Golf Courses and Residential Lawns in the South Atlantic-Gulf Region

Publications

- Water Resources Research Institute Reports:
  - Massey, Joseph, B. Stewart, C. Smith, P.Ampim, A. Johnson and K. Armbrust, 2006, Improved Estimation of Nutrient and Pesticide Runoff Losses from Golf Courses and Residential Lawns in the South Atlantic-Gulf Region, Mississippi Water Resources Research Institute, Mississippi State University, Mississippi State, MS, 17 pages.

Report Follows

MS WRRI Competitive Grants

Interim Final Report

Project title:

Improved Estimation of Nutrient and Pesticide Runoff Losses from Golf Courses and Residential Lawns in the South Atlantic-Gulf Region

Principal investigator:

Joseph H. Massey, Department of Plant & Soil Sciences, Mississippi State University

Co-Investigators: Barry R. Stewart[1], M. Cade Smith[1], Peter A. Ampim[1], Alton B. Johnson[2], Kevin L. Armbrust[3]

[1]Department of Plant & Soil Sciences, Mississippi State University; [2]Mississippi River Research Center, Alcorn State University, Alcorn State, MS; [3]Mississippi State Chemical Laboratory; Mississippi State University

Project Objectives:

1) Develop a standardized protocol to measure turf chemical runoff in different regions of the United States.

2) Determine the "scalability" of turf runoff events from three runoff plot sizes.

3) Determine if species and mowing height impact pesticide runoff for two warm-season grasses.

Project update:

Objective One: Protocol Development

As reported previously, a field protocol was developed in 2003 and is being used in the conduct of runoff studies in MD, MN, MS and OK. The protocol features the use of three simultaneously-applied pesticides (2,4-D herbicide, flutolanil fungicide, chlorpyrifos insecticide) and rainfall simulation performed under standardized study conditions.

Objective Two: Scalability Effects on Pesticide Runoff

Studies were conducted in 2005 on two of the three plot sizes necessary for completion of objective two. Replicated runoff experiments involving six small (12 x 30-ft) and four medium (20 x 80-ft) plots were performed. The large plot (40 x 125-ft) experiments will be completed in 2006. Figures 1 through 3 show experiments involving the medium-sized plots conducted in 2005. Preliminary statistical comparisons between runoff parameters (e.g., initial slope of chemographs, maximum observed concentration, average observed concentration, percent of applied observed in runoff) of the small and medium plot data are underway.

Objective Three: Effect of Two Grass Species & Two Mowing Heights on Pesticide Runoff

Studies were conducted in 2005 on twelve 12- x 30-ft runoff plots. The plots consisted of six *Mississippi Pride* bermudagrass plots maintained at a height of 0.625-in. or 1.5-in. (three plots each height) or six *Meyers* zoysiagrass plots maintained at heights of 0.625-in or 1.5-in (three plots each height). The Mississippi Pride plots were established by sprigging in August 2003 while the Meyers zoysiagrass plots were established using commercial sod in July 2004. Thus, the runoff plots were at least 13 months (zoysia) to 24 (bermuda) months old at the time of study conduct. The treatments were arranged using a split-plot design with mowing height as the main-plot factor and grass species as the sub-plot factor. Figures 4 though 6 depict some of the small-plot experiments conducted in 2005.

As anticipated, 2,4-D, flutolanil, and chlorpyrifos behaved differently when applied to the two warm-season grasses investigated in this study. 2,4-D was the most prone to runoff of the compounds with an average of 31.9 ± 14.0% of the applied herbicide measured in runoff after 1.5-in/hr simulated rainfall was applied for 1.5 hrs. Chlorpyrifos was the least mobile and averaged 0.1 ± 0.1% of applied while runoff of futolanil fungicide averaged 6.1 ± 1.9% of applied. These values are based on a total of 12 observations for each compound averaged across both grass species and mowing heights. Representative chemo-graphs for the three pesticides are given in Figure 7.

In terms of grass-species and mowing-height effects on pesticide runoff, the total percent of applied 2,4-D herbicide measured in runoff was not impacted by grass species ($p = 0.5075$) or mowing height ($p = 0.2468$) (Table 1). The rising (initial phase) slopes of the 2,4-D chemographs were also unaffected by grass species ($p = 0.8145$) and mowing height ($p = 0.4364$). Thus, the runoff of 2,4-D did not seem to be affected by physical or chemical differences that may exist between the two warm-season grasses investigated in this study.

The total percent of applied flutolanil fungicide measured in runoff was impacted by grass species ($p = 0.0187$) but not mowing height ($p = 0.2446$). On average, 7.2 ± 0.6% of applied flutolanil was lost from the Mississippi Pride bermudagrass plots as compared to 5.0 ± 0.6% loss from the Meyers zoysiagrass plots. The rising (initial phase) slopes of flutolanil's chemographs were also slightly affected by species ($p = 0.0938$) but not height ($p = 0.2015$). These p-values are given in Table 1.

The total percent of applied chlorpyrifos insecticide measured in runoff was affected ($p = 0.0178$) by an interaction that existed between grass species and mowing height (Table 1). Runoff percentages of chlorpyrifos from Mississippi Pride bermudagrass and Meyers zoysiagrass were not different when maintained at the 1.5 in mowing height (average loss = 0.08 ± 0.01% of applied) but diverged when the grasses were maintained at the 0.625-in mowing height (0.1 ± 0.02% vs. 0.2 ± 0.02% runoff for Meyers zoysiagrass and Mississippi Pride bermudagrass, respectively.) Similarly, the rising (initial phase) slopes of chlorpyifos's chemographs were slightly affected by a species x height interaction ($p = 0.0887$).

In terms of water movement across the different grass species- and mowing height-treatments, total runoff volumes (L) estimated for the 12 x 30-ft plots were unaffected by species ($p = 0.7426$) and height ($p = 0.3020$). The average total volume of water collected from the plots was estimated to be 1276.9 ± 330.5 L. The theoretical amount of simulated rainfall applied to the plots was 1912 L, suggesting that approximately 67% of the applied rainfall became runoff. Similar to total runoff volumes, rising (initial phase) slopes of the hydrographs were unaffected by species ($p = 0.8268$) and height ($p = 0.6097$). This was also true for the effect of grass species ($p = 0.7858$) and mowing height ($p = 0.2309$) on steady-state runoff (L/hr). The average rising (initial phase) slope of the hydrographs was 1226.5 ± 590.5 L/hr and the steady-state slope was 19.6 ± 4.2 L/hr when averaged across for both grass species and mowing heights.

Taken together, preliminary analyses suggest that differences in pesticide runoff from the two warm-season turfgrasses investigated result primarily from pesticide- and grass-related factors that affect pesticide sorption/retention rather than differences in water movement (i.e., hydrology) that might exist between the two grass species. These preliminary analyses suggest that future runoff estimations for pesticides having moderate to high sorption to these grasses, such as flutolanil and chlorpyrifos, may need to account for differences in retention that exist between Mississippi Pride bermudagrass and Meyers zoysiagrass. Weakly-bound compounds such as 2,4-D appear to be less affected by pesticide retention properties of the two warm-season grasses.

Adsorption-Desorption Coefficients for 2,4-D, flutolanil, and chlorpyrifos

The soil-water partition coefficients (Kd values) and Koc values measured for the three pesticides on a Brooksville silty clay closely correlated with the actual runoff levels observed in the field experiments (Table 3). Linearized sorption and desorption isotherms, shown in Figures 8 through 10, indicate that 2,4-D was weakly bound and remained in solution, resulting in higher desorption Kd values. Results for flutolanil suggested that the fungicide was strongly adsorbed to soil while chlorpyrifos insecticide was tightly bound to soil. These results suggested that 2,4-D has high runoff potential while that of flutolanil fungicide and chlorpyrifos insecticide are diminished due to strong binding.

Current Efforts

Statistical analyses continue for objectives two and three. Work to complete installation of collection troughs, diverters, and flumes for the four large (40- x 125-ft) plots will continue through Spring 2006, weather permitting. The runoff experiments to complete objective two will resume in summer and will be completed by winter 2006. A detailed description of field and laboratory materials and methods will be provided in the final project report submitted in 2006.

Procurement of Matching Funds

As of May 2006, approximately $192,500 was secured to supplement funding received from the USGS for the conduct of these studies. Funding sources and amounts are given in Table 4.

Table 1. p-values from preliminary statistical analyses of grass species and mowing height effects on pesticide runoff losses from two warm-season turfgrasses.[1]

Compound	**Runoff Parameter Tested**	**Mowing Ht x Species Interaction**	**Grass Species**	**Mowing Height**
2,4-D herbicide	Total Percent of Applied in Runoff	0.4140	0.5075	0.2468
	Total mass Lost	0.8244	0.6242	0.0824
	Rising slope of chemograph	0.9655	0.8145	0.4364
Flutolanil fungicide	Total Percent of Applied in Runoff	0.6295	**0.0187**	0.2446
	Total mass Lost	0.4348	**0.0197**	0.2015
	Rising slope of chemograph	0.3794	**0.0938**	0.2082
Chlorpyrifos insecticide	Total Percent of Applied in Runoff	**0.0178**	0.0114	0.0310
	Total mass Lost	**0.0451**	0.0169	0.0248
	Rising slope of chemograph	**0.0887**	0.1150	0.1909

[1]Results based on three replications per treatment. Factors significant at $p < 0.1$ are in bold.

Table 2. p-values from preliminary statistical analyses of grass species and mowing height effects on hydrological parameters for two warm-season turfgrasses.[1]

Runoff Parameter Tested	**Mowing Ht x Species Interaction**	**Grass Species**	**Mowing Height**
Rising slope of hydrograph (L/hr)	0.5797	0.8268	0.6097
Steady-state runoff of hydrograph (L/hr)	0.3696	0.7858	0.2309
Total runoff Volume (L)	0.5359	0.7426	0.3020

[1]Results based on three replications per treatment.

Table 3. Soil-water distribution (Kd) values and Koc values for three pesticides on the Brooksville silty clay soil.

Pesticide	Kd sorption (ml/g)	Kd desorption (ml/g)	Koc sorption (ml/g)	Koc desorption (ml/g)	Extent of Soil Adsorption	Turf Runoff Potential
2,4-D	1.5	3.6	72.83	177.9	Weakly bound	High
Flutolanil	11.5	13.5	576.1	673.6	Strongly bound	Low
Chlorpyrifos	71.0	52.7	3550.8	2635.4	Tightly bound	Very low

Table 4. Supplemental funding received for study conduct as of May 2006.

Source	Amount	Use
MAFES-Mississippi State University[1]	$95,000[2]	Laser-leveling of site, sprigging, irrigation system, graduate student support, triplex mower, enlargement of equipment shed
U.S. Golf Association	$97,500	Comparison of fairway vs. home lawn runoff
Total	**$192,500**	

[1]Mississippi Agriculture & Forestry Experiment Station (MAFES).
[2]Figure does not included salaries of PI (Massey) or Co-PIs (Stewart, Smith, Armbrust)

Figure 1. Evening application of KBr tracer to 20 x 80-ft plot in October 2005.

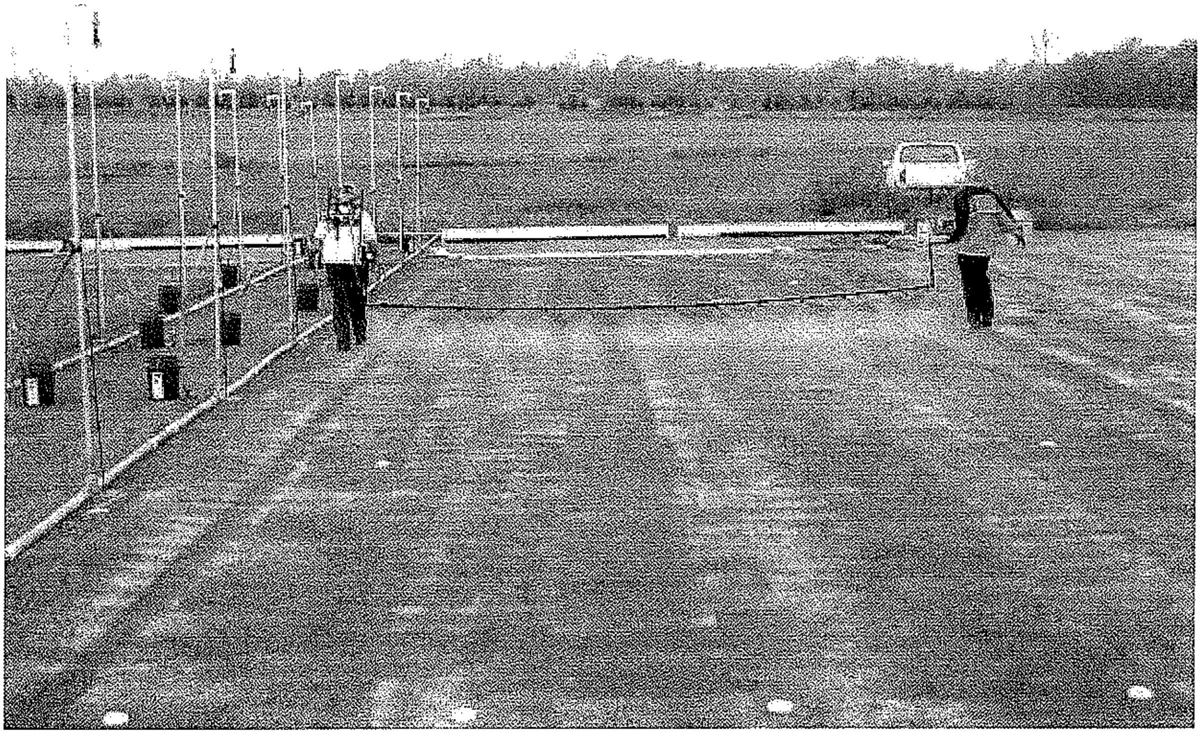

Figure 2. Early morning rainfall simulation event for 20 x 80- ft plots in October 2005.

Figure 3. Collection of runoff from 20 x 80-ft plot in October 2005.

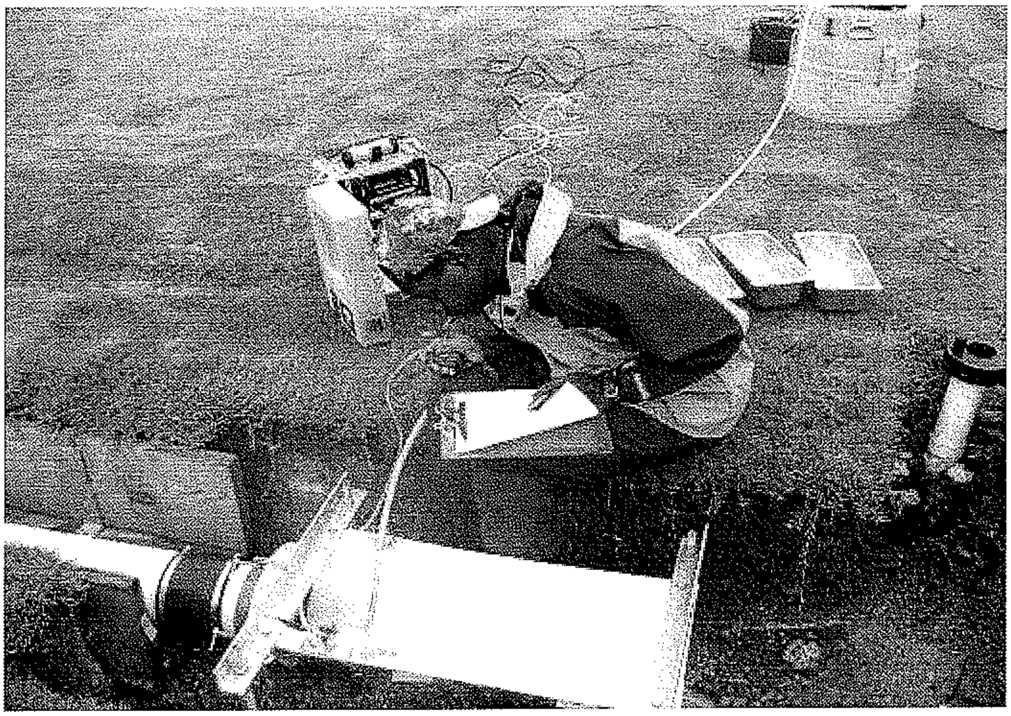

Figure 4. Pesticide application to 12 x 30-ft plot in August 2005.

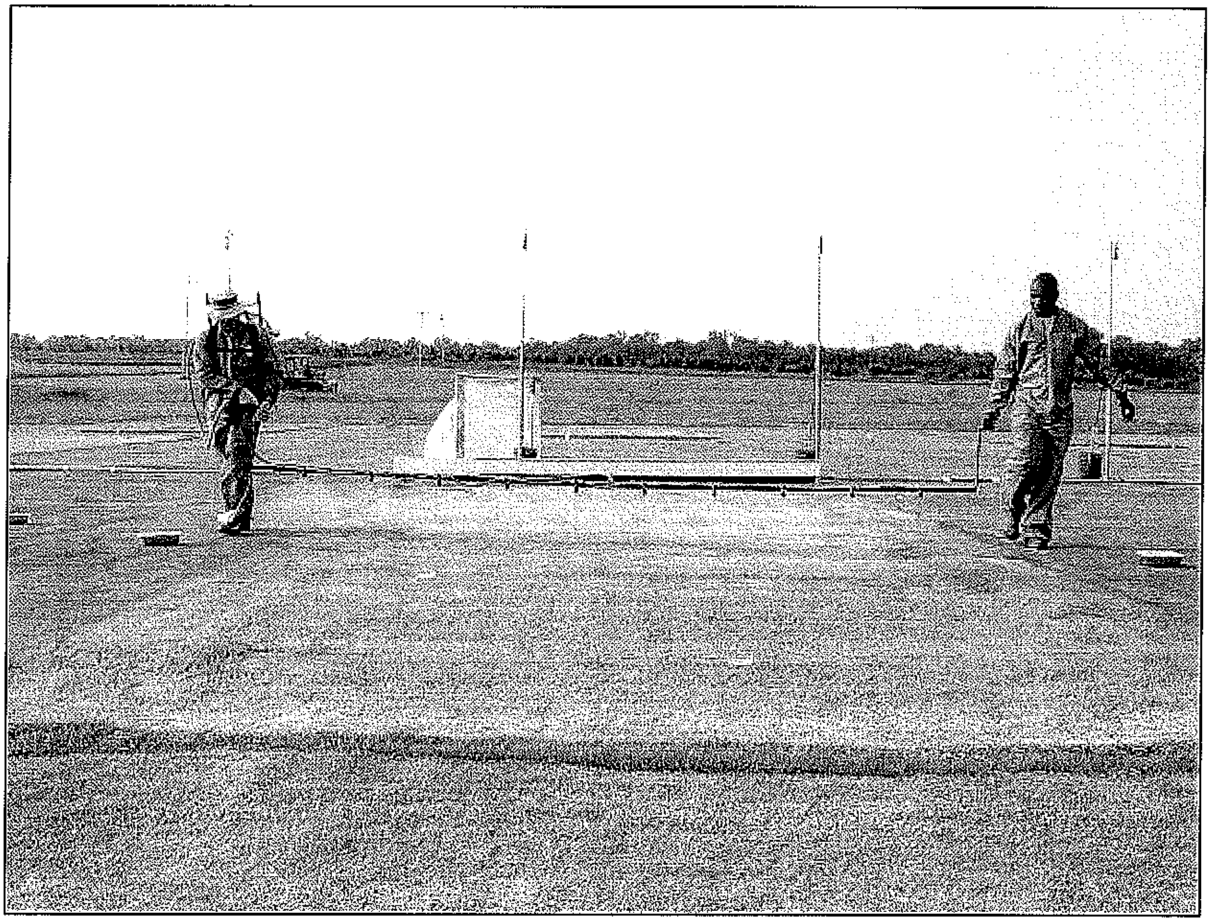

Figure 5. Rainfall simulation event for 12 x 30-ft plots in August 2005. Six rainfall gauges (metal pans) per plot and one plastic tarp (foreground) per block used to confirm actual simulated rainfall application rate.

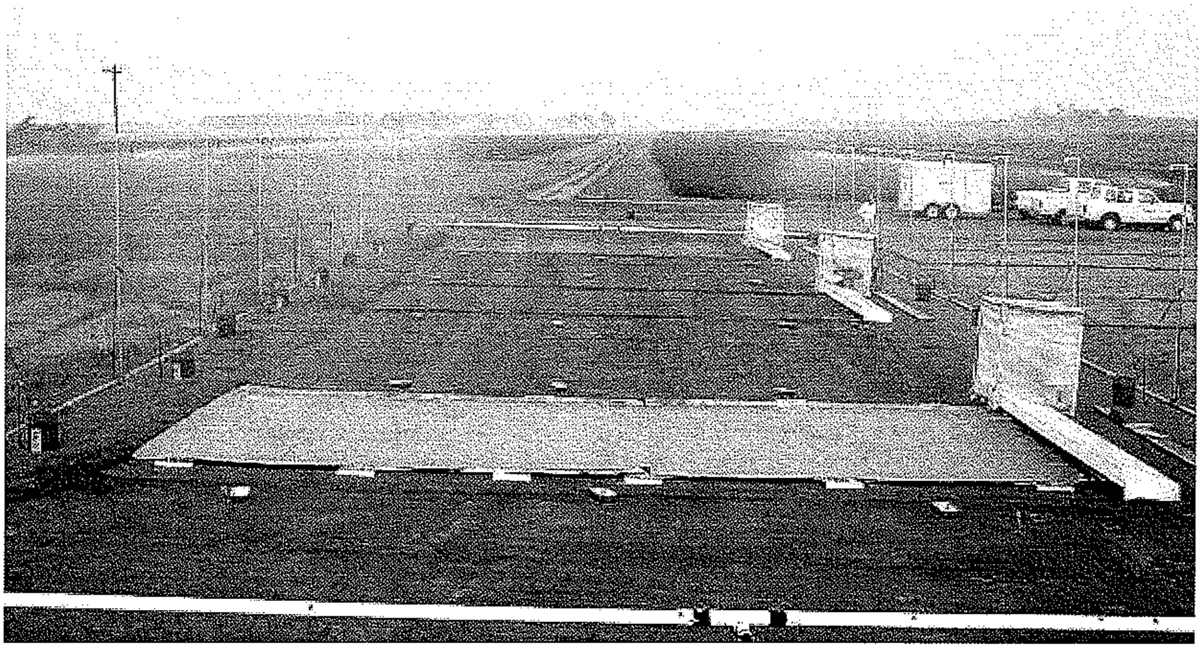

Figure 6. Close-up of runoff collection apparatus used for 12 x 30-ft plots (August 2005).

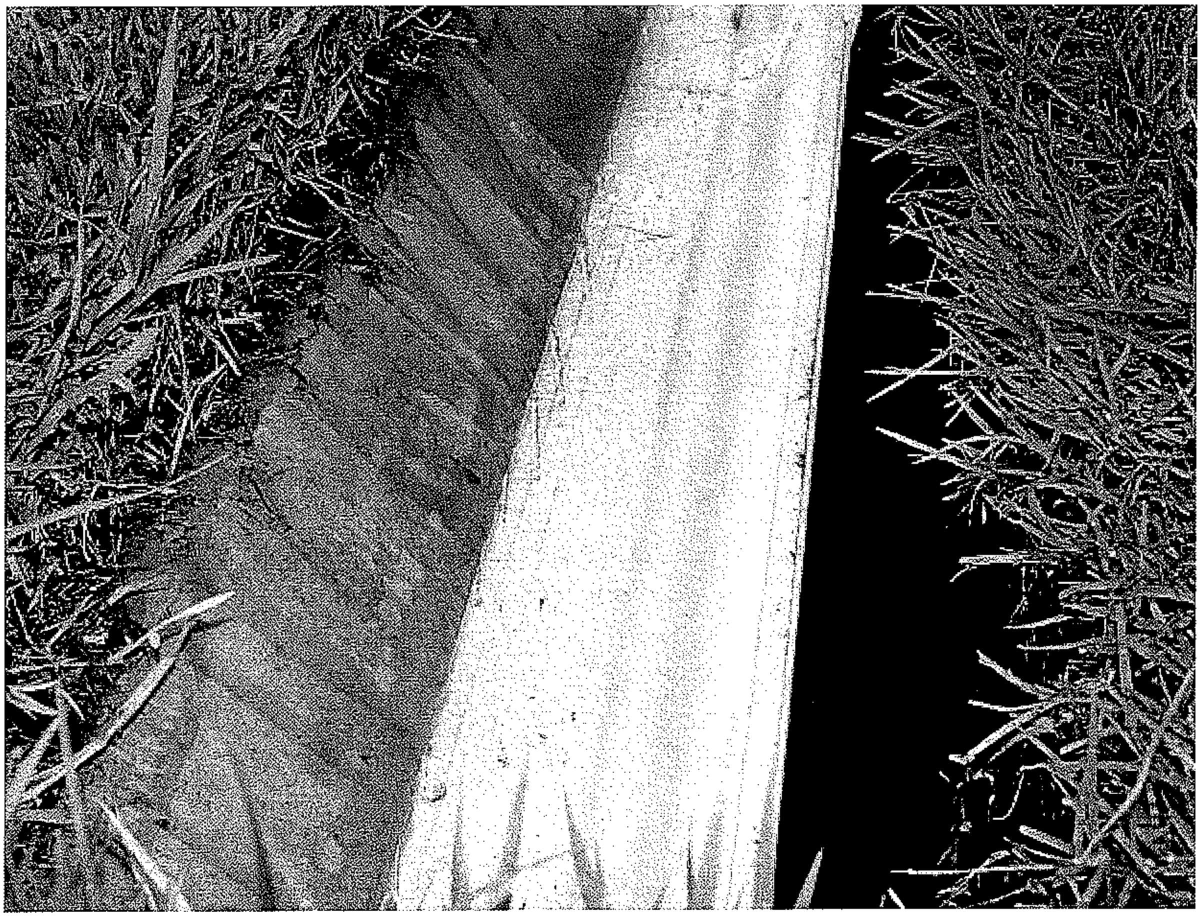

Figure 7. Example chemo-graphs for the runoff of three pesticides applied to 12 x 30-ft warm-season turf plots.

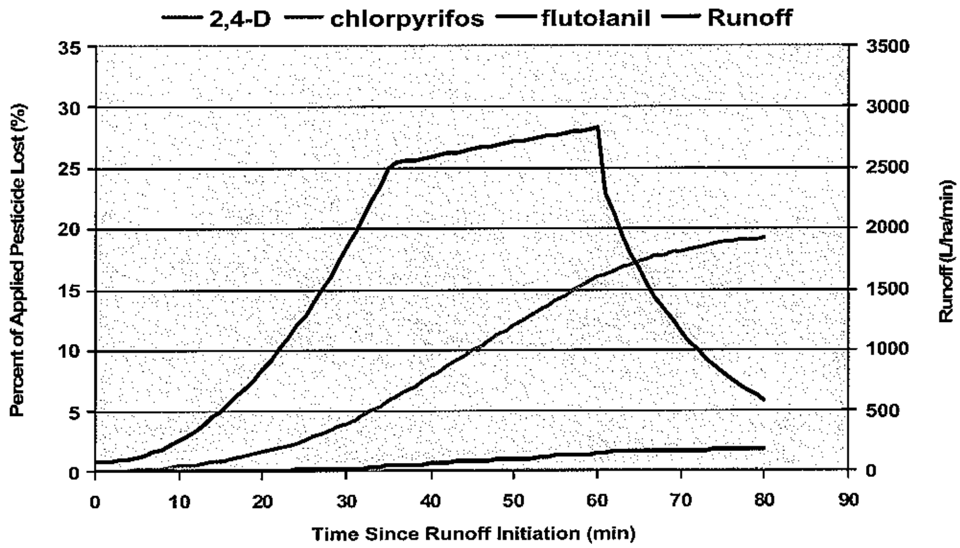

Figure 8. Adsorption-desorption isotherm for ^{14}C-2,4-D herbicide on Brooksville silty clay.

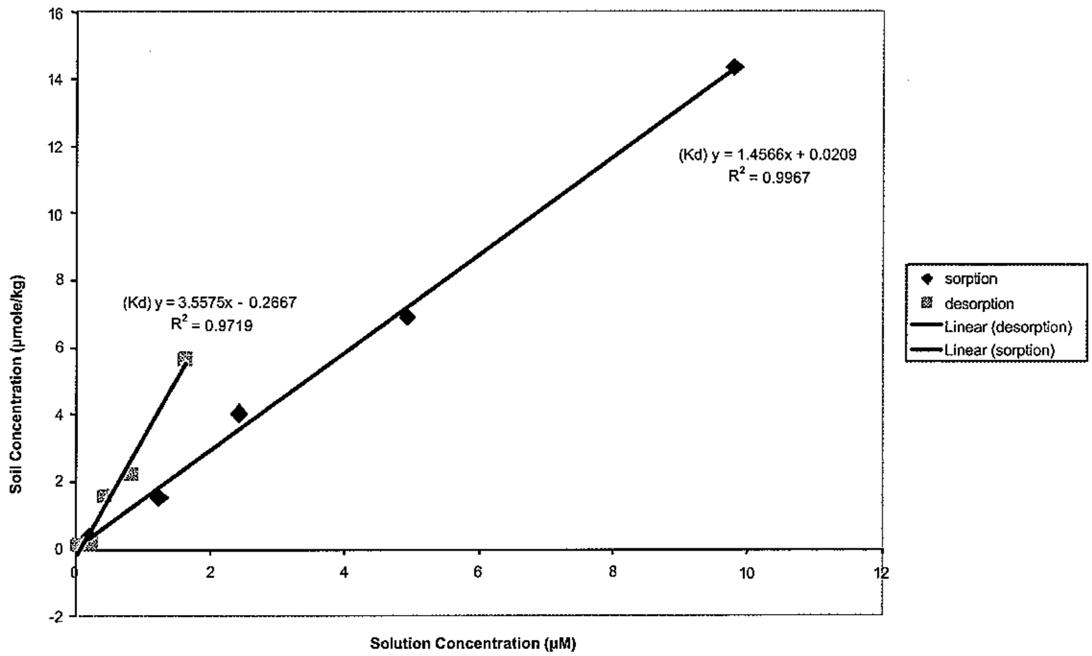

Figure 9. Adsorption-desorption isotherm for ^{14}C-chlorpyrifos insecticide on Brooksville silty clay.

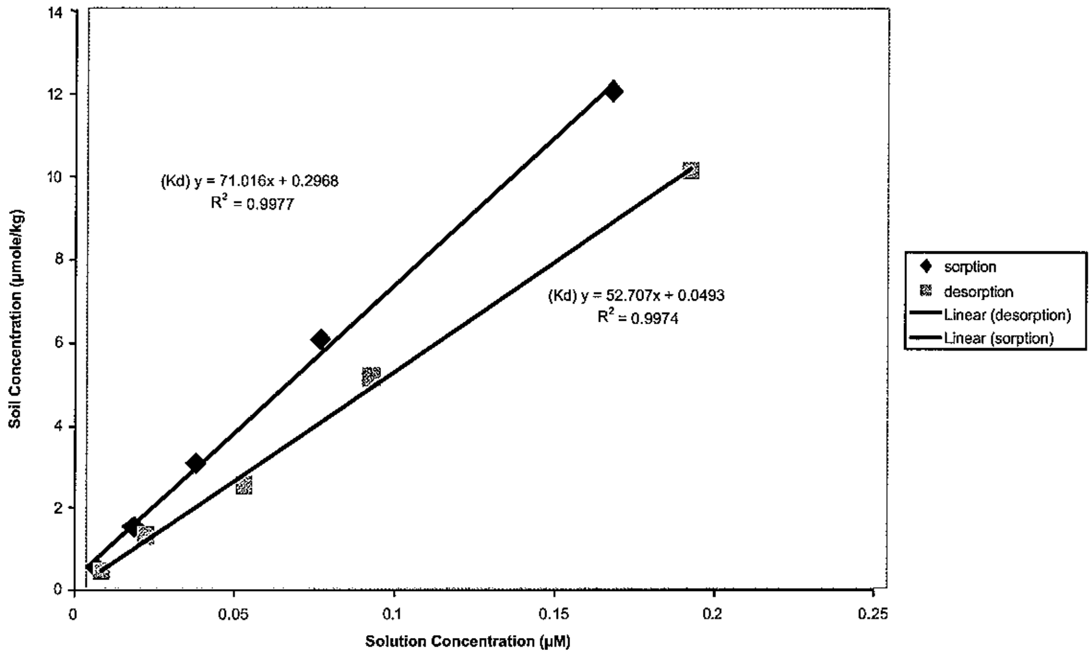

Figure 10. Adsorption-Desorption Isotherm for ^{14}C-Flutolanil on Brooksville silty clay soil.